

To Dr. Manning
with best wishes
Karasawa

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THE CENOZOIC DECAPOD CRUSTACEAN FAUNA OF SOUTHWEST JAPAN

BY

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ABSTRACT

The known Cenozoic decapod Crustacea from southwest Japan comprise 153 species in 90 genera. The Cenozoic fauna is divided stratigraphically into ten units (i.e., middle Eocene, early Oligocene, late Oligocene, early Miocene, early middle Miocene, middle middle Miocene, late middle Miocene, latest Miocene-early Pliocene, late Pliocene, Pleistocene-Holocene). The fauna has a close affinity to the western Tethys fauna in the middle Eocene, but it appears to become endemic in the early Oligocene. It contains a high percentage of Indo-West Pacific genera after the early Miocene. The Miocene endemic genera became extinct in the early-middle middle Miocene. The early middle Miocene fauna is characterized by *Thalassina* Latreille, *Ozius* H. Milne Edwards, *Glabropilumnus* Balss, *Daira* De Haan, and *Euryozius* Miers, which currently live in tropical seas. Occurrences of these genera demonstrate tropical palaeoenvironments in southwestern Honshu at that time. During the Neogene, major changes of the fauna are recognized four times in close relation to climatic events. This phenomenon suggests that species migrated from the low latitude areas to Japan during warming events and that extinction of them was caused by cooling events during the Neogene.

INTRODUCTION

Since De Haan (1835) first described *Arges parallelus* as a new species of Japanese fossil decapod Crustacea, many workers have studied systematics of Japanese fossil decapods. Imaizumi (1978) summarized fossil records of decapods known from Mesozoic and Cenozoic deposits from Japan. After 1989 there have been descriptive and palaeoecological works on local faunas from various localities in Japan in addition to systematics and descriptions of fossil decapods. Examples are faunal descriptions and palaeosynecological studies of the Mizunami Group (Karasawa, 1991), the Izumo Group (Sakumoto, Karasawa & Takayasu, 1992), the Manda Group (Karasawa, 1992a), the Kakinaga Group (Karasawa & Inoue, 1992), the Morozaki Group (Mizuno & Takeda, 1993), the Chichibumachi Group (Kato, 1996), the Katsuta Group (Karasawa & Kishimoto, 1996), and the Bihoku Group (Sakumoto, 1997).

Karasawa (1993) recorded 119 species in 73 genera of decapods from Cenozoic deposits of southwest Japan and first discussed the geochronological change of the Cenozoic fauna in view of the palaeobiogeography and climatic changes during the Neogene. In this paper, I re-examine the geochronological changes within the Cenozoic fauna to add to subsequent fossil records from southwestern Japan.

FAUNAL ASPECTS

The material was collected from 44 formations at about 200 localities in southwest Honshu, Shikoku, Kyushu, and Ryukyu Islands (fig. 1). The stratigraphic classification and distribution of the decapod-bearing formations are shown in figs. 1 and 2. The geologic range of each formation is based on several micropalaeontological data, fission track ages, and radiometric ages by Chiji & IGCP-246 National Working Group of Japan (1989), Endo & Suzuki (1986), Fu-

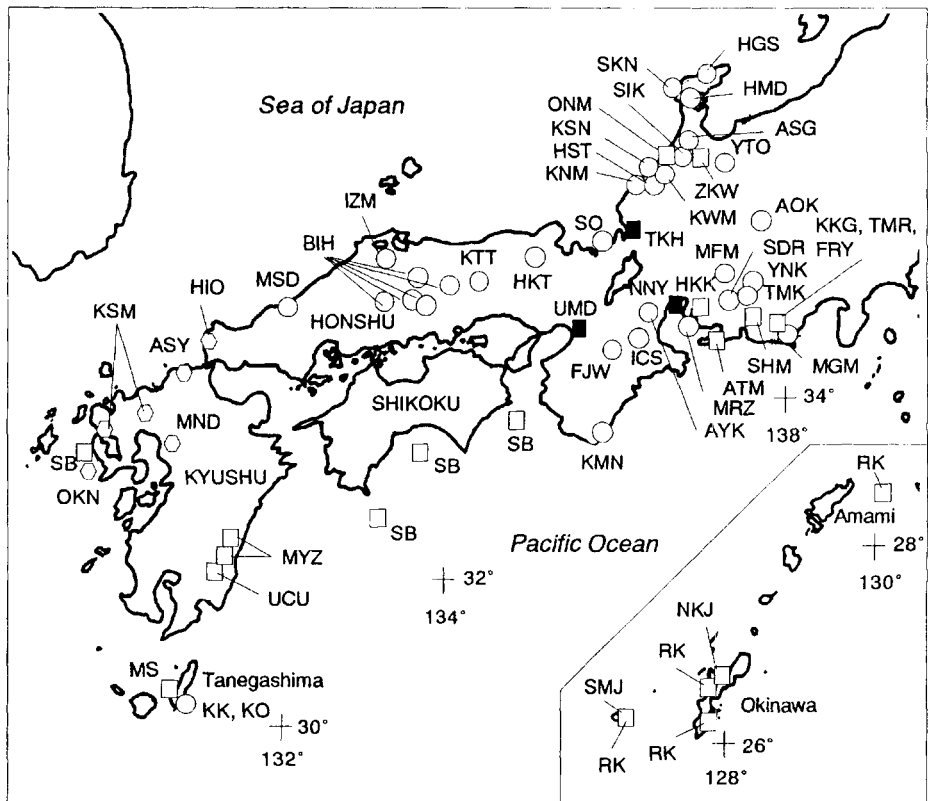


Fig. 1. Map showing decapod-bearing localities from southwest Japan. Hexagon, Palaeogene; open circle, early-middle Miocene; open square, late Miocene-Pleistocene; solid square, Holocene localities.

jii, Kaseno & Nakagawa (1992), Ibaraki (1986), Nakagawa & Murakami (1975), Nirei, Shibata & Akaba (1988), Ozaki & Hamasaki (1991), Shimamoto et al. (1994), and Takayasu et al. (1992). Karasawa (1993, 1997a) gave detailed information of locality data and of decapod taxa occurring at each locality. A total of 153 species in 90 genera is now known from Cenozoic deposits in southwest Japan.

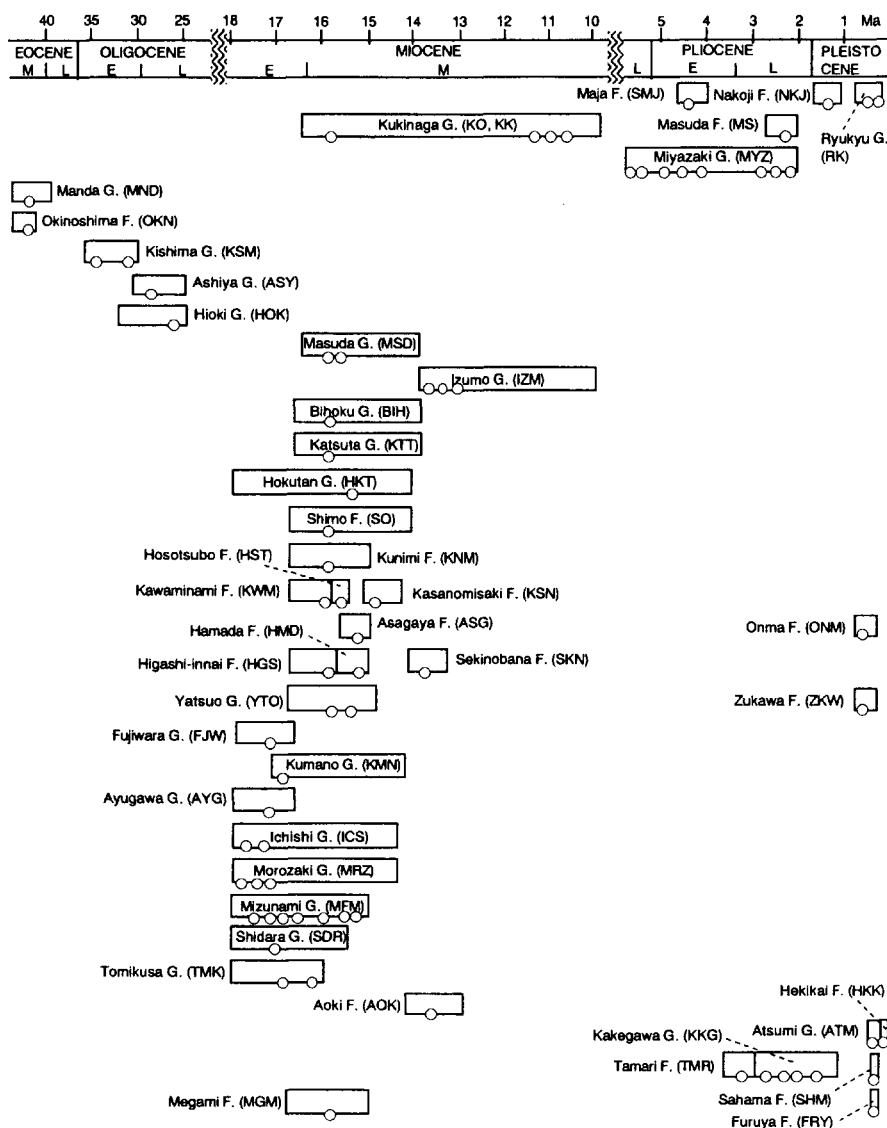


Fig. 2. Stratigraphic correlation of decapod-bearing formations from southwest Japan. Open circle indicates an approximate decapod-bearing horizon.

Thirty-four types decapod assemblages, which are characterized by dominant species, are recognized from southwest Japan (fig. 3). Considering the change of decapod assemblages, based on the geological age of decapod-bearing formations, Karasawa (1993) divided the Cenozoic fauna into ten stratigraphic units. They are the middle Eocene, early Oligocene, late Oligocene, Neogene I (early Miocene), Neogene II (early middle Miocene), Neogene III (middle middle Miocene), Neogene IV (late middle Miocene), Neogene V (latest Miocene-early

Assemblage	Age	Eo		Oligo			Miocene				Plio		Pleist
		M	E	L	I	II	III	IV	V	VI			
Intertidal - Upper sublittoral facies	<i>'Neocallichirus' okamotoi</i>												
	<i>Upogebia mizunamiensis</i>												
	<i>'Neocallichirus' bona</i> - <i>Philyra nishimotoi</i>												
	<i>Miosesarma japonicum</i> - <i>Philyra nishimotoi</i>												
	<i>Upogebia tanegashimensis</i>												
	<i>Thalassina anomala</i>												
	<i>Callinassa nishikawai</i>												
	<i>Eucalliax yatsuoensis</i> - <i>C. nishikawai</i>												
	<i>Miosesarma japonicum</i>												
	<i>Laurentiella imaizumii</i>												
	<i>Tymolus itoigawai</i> - <i>Philyra plana</i>												
	Xanthid - Grapsid												
	<i>Petrolisthes miocaenicus</i> - <i>Medaëops</i> <i>megamiensis</i> - <i>Galathea keijii</i>												
	<i>Carcinoplax antiqua</i>												
	<i>Macrophthalmus viai</i>												
	<i>Macrophthalmus leptophthalmus</i>												
	<i>Macrophthalmus</i> sp. aff. <i>M. japonicus</i>												
<i>'Neocallichirus' grandis</i>													
Lower sublittoral - Upper bathyal facies	<i>Eucalliax yoshihiroii</i> - <i>Raninoides nodai</i>												
	<i>Collinsius simplex</i>												
	<i>Miosesarma japonicum</i> - <i>Carcinoplax antiqua</i>												
	<i>Trachycarcinus huziokai</i>												
	<i>Callianopsis titaensis</i>												
	<i>Platopistoma kaedei</i>												
	<i>Carcinoplax antiqua</i>												
	<i>Mursia takahashii</i>												
	<i>Carcinoplax granulimanus</i>												
	<i>Carcinoplax prisca</i>												
	<i>Carcinoplax prisca</i> - <i>Mursia minuta</i>												
	<i>Eucalliax miyazakiensis</i>												
	<i>Carcinoplax</i> sp.												
	<i>Carcinoplax longimanus</i>												
	<i>Philyra platychira</i>												
<i>Padocactes hamifer</i>													

Fig. 3. Stratigraphic distribution of decapod assemblages from the Cenozoic of southwest Japan.

Pliocene), Neogene VI (late Pliocene), and Pleistocene-Holocene faunas, in ascending order (fig. 3).

Middle Eocene. — Five species in five genera known from the Manda Group and Okinoshima Formation in northwest Kyushu (Karasawa, 1992a, 1997a) represent the middle Eocene fauna. Both *Eucalliax* Manning & Felder and *Ranioides* H. Milne Edwards have extant species, whilst *Prohomola* Karasawa, *Portunites* Bell, and *Branchioplax* Rathbun, restricted to the Palaeogene, are the Tethyan genera. The occurrences of these genera show that the fauna has close affinities with those of the western-central Tethys realm.

Early Oligocene. — The early Oligocene decapod fauna is known from the Kishima Group in northwestern Kyushu (Karasawa, 1993, 1997a). It consists of five species in five genera and is characterized by the abundant occurrence of the Japanese early Oligocene endemic genus *Collinsius* Karasawa. Among the known genera, *Ctenocheles* Kishinoue and *Callianassa* Leach are cosmopolitan. *Varuna* H. Milne Edwards, known from the Eocene of Europe, is the Tethys-Indo-West Pacific genus. These decapods have nothing in common with those of the middle Eocene fauna. The Tethyan genera seem to disappear by the Oligocene and the Japanese decapod fauna appears to become endemic into the early Oligocene.

Late Oligocene. — Late Oligocene decapods are sparse in Japan and only two species, *Neocallichirus okamotoi* Karasawa, 1993 from the Hioki Group (Karasawa, 1993) and *Minohellenus macrocheilus* Kato & Karasawa, 1994 from the Ashiya Group (Kato & Karasawa, 1994) are known. *Minohellenus* Karasawa is a Japanese late Oligocene-middle Miocene endemic genus.

Neogene I (Early Miocene; 18-16 Ma). — The early Miocene fauna is represented by 36 species in 31 genera recorded from central Honshu (Karasawa, 1997a). It contains six Indo-West Pacific genera and one Tethys-Indo-West Pacific genus. Indo-West Pacific genera, not derived from the Palaeogene of the Tethys, predominate after the early Miocene.

The following extinct genera are known from lower Miocene rocks: *Itoigawaia* Karasawa and *Miosesarma* Karasawa are endemic elements of the Japanese Miocene fauna; *Minohellenus* is an endemic genus that appeared in the late Oligocene; *Laurentiella* Le Loeuff & Intès and *Callianopsis* De Saint Laurent are not distributed at present in Japanese waters. The extant species of *Laurentiella* are only recorded from the tropical East Atlantic Ocean (Le Loeuff & Intès, 1974). The fossil record of *Callianopsis* is known from the Palaeogene of Hokkaido, Japan (Kato & Karasawa, 1994) and the Eocene to early Miocene of the U.S.A. (Schweitzer Hopkins & Feldmann, 1997), and the extant species are from the Pacific coast of North America and the Andaman Sea (De Saint Laurent, 1979).

Neogene II (Early middle Miocene; 16-15 Ma). — Decapods totaling 61 species in 48 genera have been recorded from Tanegashima Island and south-west Honshu (Karasawa, 1997a). Thirteen genera comprise Indo-West Pacific forms. In addition to *Callianopsis* and *Laurentiella*, four extinct genera are included. *Typilobus* Stoliczka is a Tethys-Indo-West Pacific genus known from the Eocene of Europe. The genus does not survive beyond the Pliocene (Karasawa, 1998). *Paramursia* Karasawa occurs outside Japan in the Oligocene of Panama (Rathbun, 1918) and in the Miocene of Taiwan (Hu & Tao, 1996). *Palaeoxanthops* Karasawa and *Megamia* Karasawa are endemic elements of the Japanese Miocene.

Most of the species that occurred in the early Miocene survived beyond the early middle Miocene and several species first appeared in shallow marine deposits of the early middle Miocene. The Katsuta local fauna (Karasawa & Kishimoto, 1996) represents a shallow marine decapod association at that time and is characterized by abundant occurrences of *Callianassa nishikawai* Karasawa, 1993, *Miosesarma japonicum* Karasawa, 1989, *Laurentiella imaizumii* Karasawa, 1993, and *Carcinoplax antiqua* (Ristori, 1889), associated with *Ozius* which are thought to have been tropical inhabitants in the early middle Miocene (Karasawa, 1992b).

Neogene III (Middle middle Miocene; 14-13 Ma). — The fauna from three formations of southwestern Honshu consists of 15 species in 12 genera and is distinguished by the absence of extinct and endemic genera (i.e., *Laurentiella*, *Miosesarma*) that occurred commonly in the early-early middle Miocene. *Itoigawaia*, the sole surviving endemic genus, becomes extinct in the middle middle Miocene. Except for four species, the component species are common to those of the middle middle and early-early middle Miocene faunas. The existence of *Cancer (Metacarcinus) izumoensis* Sakumoto, Karasawa & Takayasu, 1992 from the Izumo Group described by Sakumoto, Karasawa & Takayasu (1992) has important palaeobiogeographic implications. Most of the genera occurring in the early-early middle Miocene are thought to be tropical-subtropical elements, whilst *Metacarcinus* A. Milne-Edwards, a subgenus of *Cancer* Linnaeus, is a temperate-boreal element. Species of the subgenus flourished on the Pacific coast of North America (Nations, 1975) and are not distributed at present in Japanese waters. Representatives of the subgenus appear to have migrated from the Pacific coast of North America to Japan during the middle middle Miocene time.

Neogene IV (Late middle Miocene; 12-10 Ma). — The Osaki local fauna (Karasawa & Inoue, 1992) from the Kukinaga Group of Tanegashima Island is characterized by lacking extinct and endemic genera. Following the late middle

Miocene, the Japanese fauna exhibits a generic composition similar to the extant fauna. Three species survived beyond the early-middle Miocene, while others appear in the late middle Miocene.

Neogene V (Latest Miocene-early Pliocene; 7-4 Ma). — The late Miocene-early Pliocene fauna is represented by 29 species in 17 genera from the Miyazaki Group of southwest Honshu, and the Maja Formation of Kumejima, Ryukyus. The component species have nothing in common with those of the late middle Miocene fauna.

Neogene VI (Late Pliocene; 3-2 Ma). — Decapods from the Miyazaki and Kakegawa Groups of southwest Honshu and from the Masuda Formation of Tanegashima are of the late Pliocene age. The fauna is characterized by the first appearance of the extant species (i.e., *Mursia* sp. aff. *M. australiensis* Campbell, 1971, *Cancer japonicus* Ortmann, 1893, *Cancer amphioetus* Rathbun, 1898, *Carcinoplax longimanus* (De Haan, 1833), *Randallia eburnea* Alcock, 1896, *Philyra platycheira* De Haan, 1841), although it contains many extinct species.

Pleistocene-Holocene. — The Pleistocene fauna comprises 51 species in 32 genera from central Honshu, Ryukyu Islands, and other localities. It consists predominantly of extant species and the following four extinct species. '*Neocallichirus*' *grandis* Karasawa & Goda, 1996 described from the middle Pleistocene Atsumi Group, seems to occur in the Seto Inland Sea and Iki Island, associated with extant shell remains (Prof. T. Tanaka, pers. comm.). *Leucosia takamii* Karasawa, 1993 ranges from the upper Pliocene to the lower Pleistocene. *Macrophthalmus granulatus* De Man, 1904 occurs outside the middle Pleistocene Ryukyu Group of Okinawajima (Karasawa, Nohara & Shimoji, 1995) only in the Pleistocene of Celebes (De Man, 1904). *Macrophthalmus leptophthalmus* (H. Milne Edwards, 1852) is not distributed in the West Pacific Ocean at the present time, but the fossil record is known from the lower Pleistocene Nakoji Formation of Okinawajima (Karasawa, 1993) and from the upper Pleistocene of Taiwan (Hu & Tao, 1996) and Guam (Kesling, 1958).

In central Honshu, the Holocene decapod fauna from the Nanyo Formation reaches 57 species in 45 genera (Tokai Fossil Society, 1977; Karasawa & Umemoto, 1998). Except for *Arges parallelus*, the Holocene fauna consists of extant species. *Geothelphusa dehaani* (White, 1847) from the Yage Formation (Karasawa, 1997b) is the sole record of non-marine decapods from the Japanese Cenozoic.

The faunal characteristics of the Cenozoic decapod fauna of southwest Japan are summarized in fig. 4.

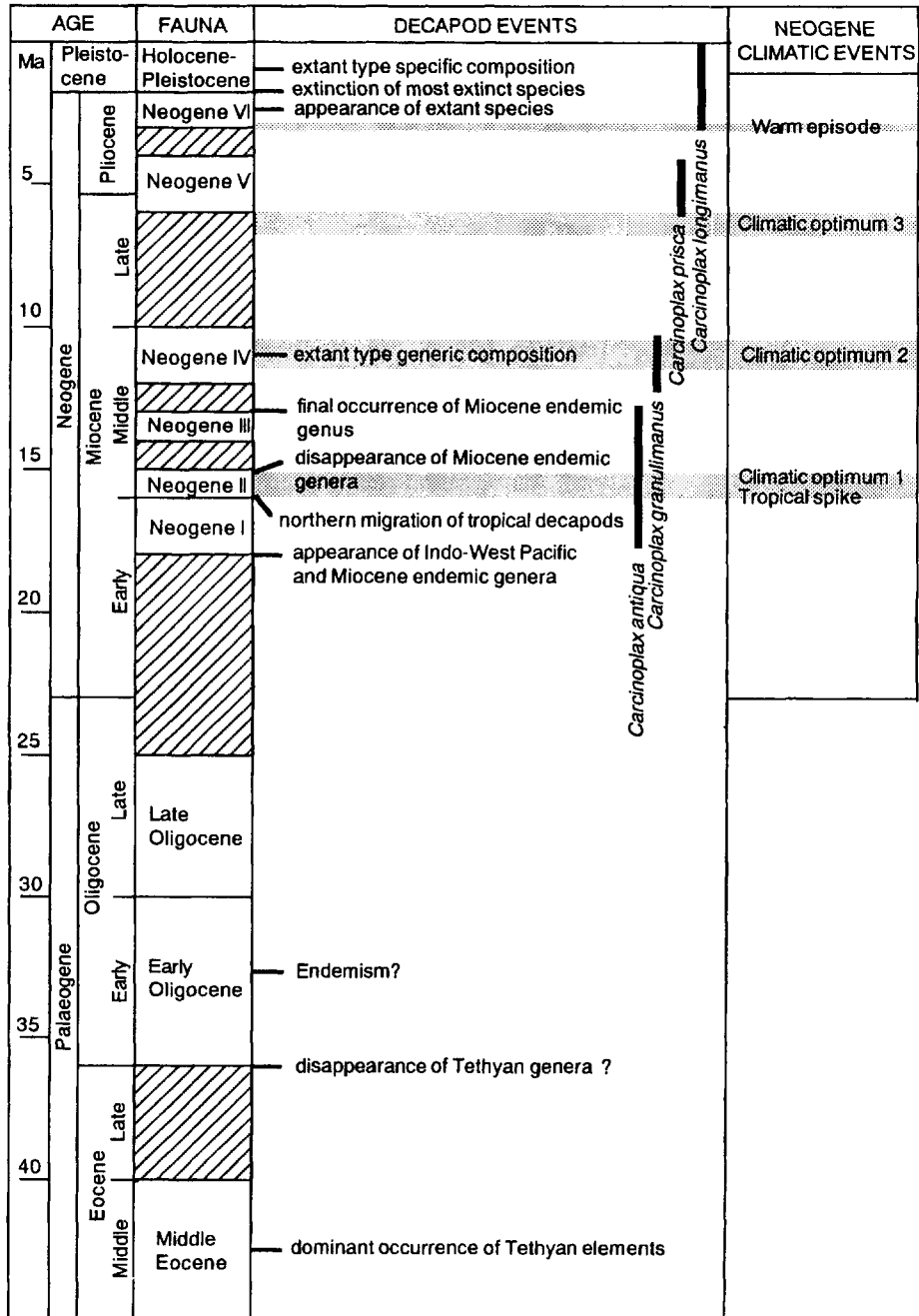


Fig. 4. Summary of the faunal characteristics of the Cenozoic decapod fauna from southwest Japan.

FAUNAL CHANGE IN RELATION TO NEOGENE CLIMATIC EVENTS

The decapod fauna appears to be characterized by occurrences of Tethyan genera in the middle Eocene and by dominant occurrences of endemic genera in the early Oligocene although decapods are generally sparse within the Japanese Palaeogene. The stratigraphic distribution of selected species within the Neogene and Pleistocene is shown in figs. 5 and 6.

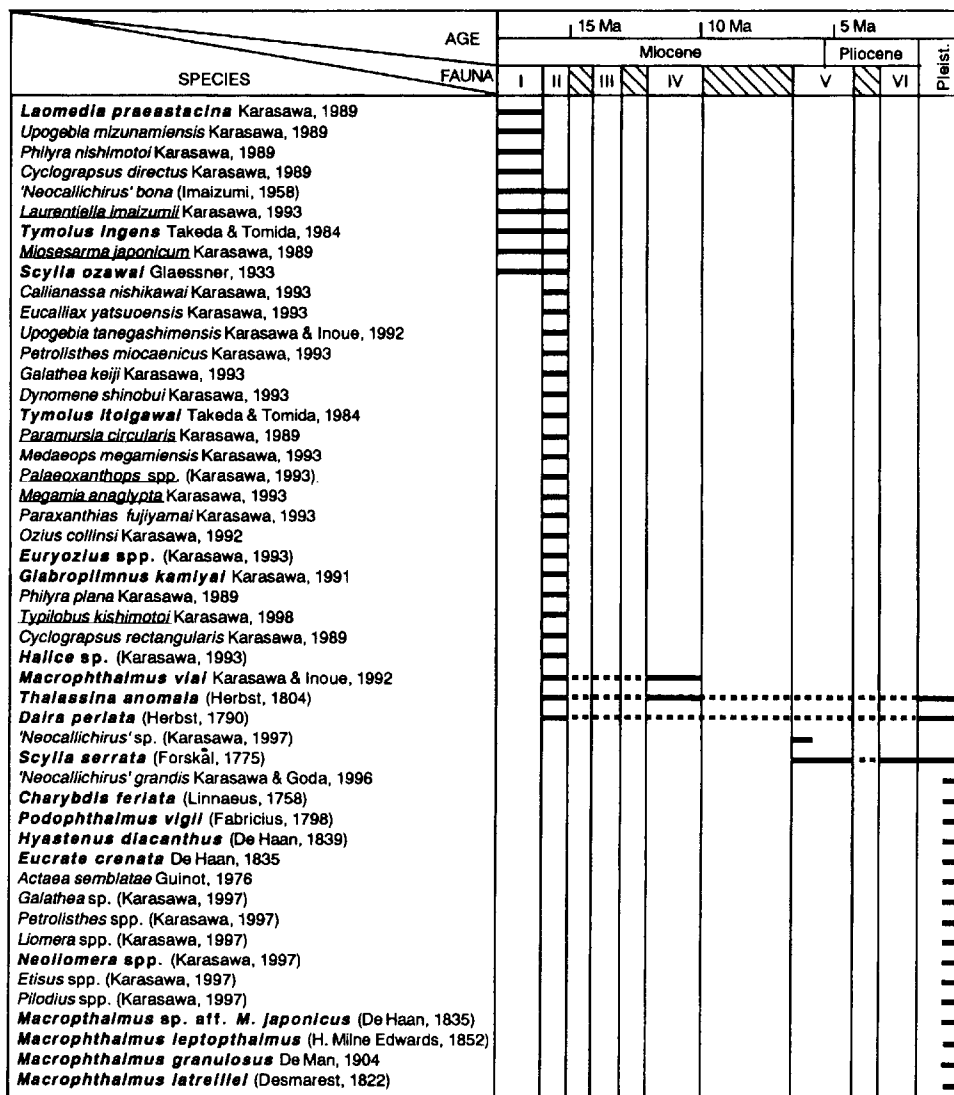


Fig. 5. Stratigraphic distribution of selected species during the Neogene and Pleistocene (inter-tidal-upper sublittoral facies). Bold type, Indo-West Pacific; underlined, endemic elements.

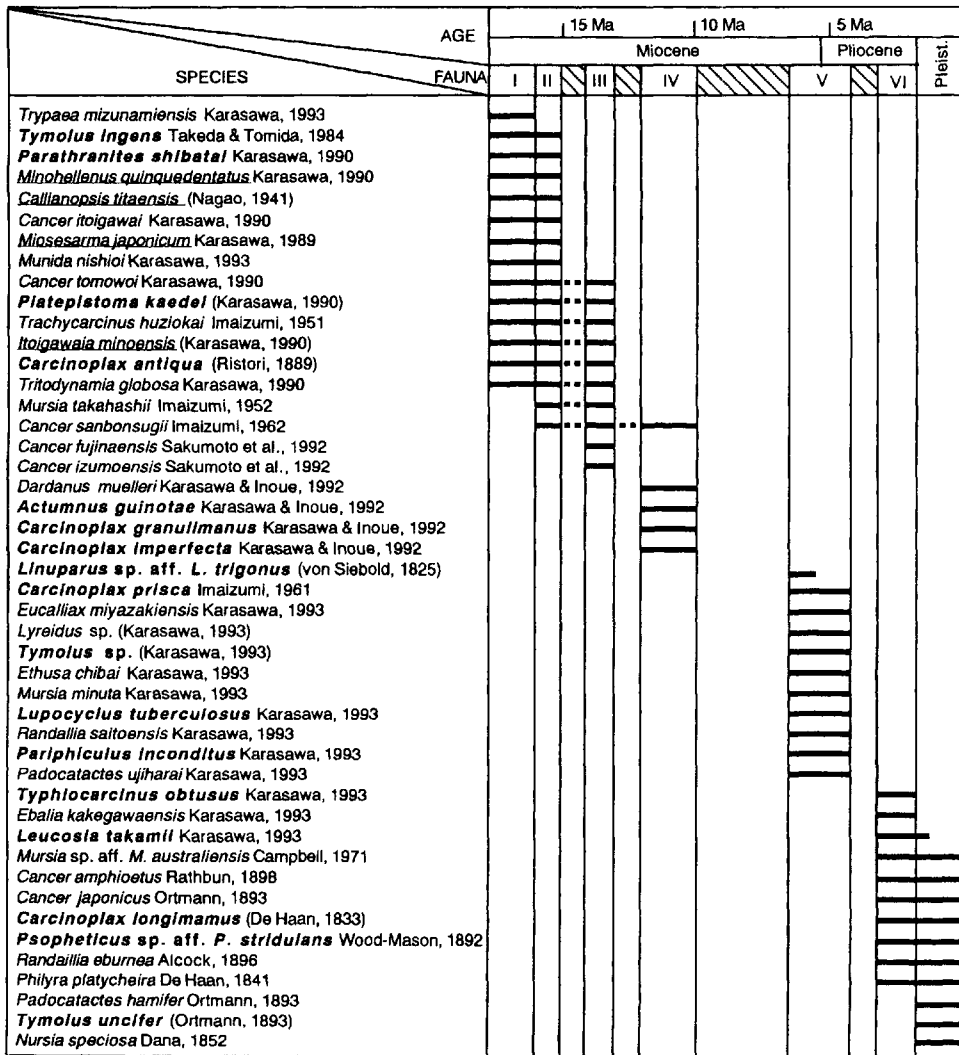


Fig. 6. Stratigraphic distribution of selected species during the Neogene and Pleistocene (lower sublittoral-upper bathyal facies). Bold type, Indo-West Pacific; underlined, endemic elements.

In the intertidal to upper sublittoral facies a major difference between the Neogene I and II is represented by a low number of common species (fig. 5). Moreover, several tropical decapods, not distributed in southwest Honshu at the present time, are found in lower middle Miocene deposits of southwest Honshu. Karasawa (1992b) summarized the records of such tropical species occurring in southwestern Honshu as *Thalassina anomala* (Herbst, 1804) from the Bihoku Group, and the Kunimi and Kawaminami Formations, *Glabropilumnus kamiyai* Karasawa, 1991 from the Mizunami Group, and *Ozium collinsi* Karasawa, 1992

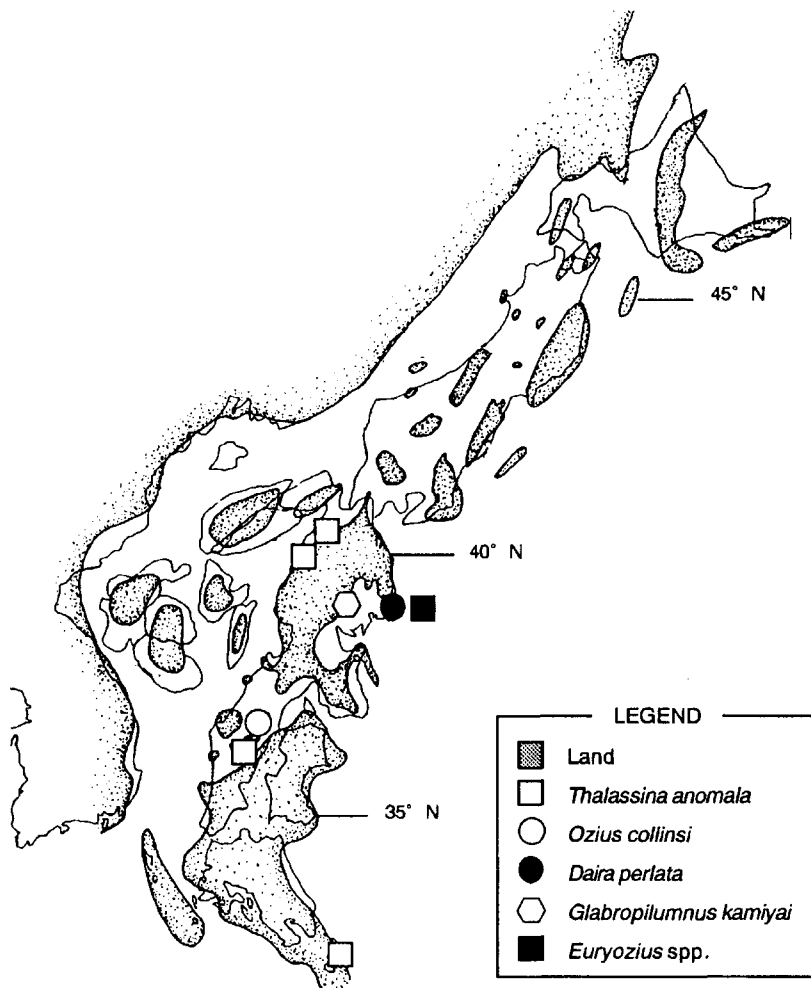


Fig. 7. Palaeogeographic map of Japan in the early middle Miocene (modified from Ogasawara & Nagasawa, 1992) and geographic distribution of tropical decapods.

from the Katsuta Group (fig. 7). Additional records are *Daira perlata* (Herbst, 1790) and *Euryozius* spp. from the Megami Formation described by Karasawa (1993) (fig. 7). The northern limits of these extant species and/or species which are allied to fossil species are shown in fig. 8. The occurrences of these species document tropical marine palaeoenvironments in southwestern Honshu in the early middle Miocene (Karasawa, 1992b). These decapods appear to have migrated from low latitude areas to southwest Honshu in the early middle Miocene in relation to the “tropical spike”, a mid-Neogene climatic event characterized by the northern migration of the tropical molluscan fauna at that time (Itoigawa, 1989).

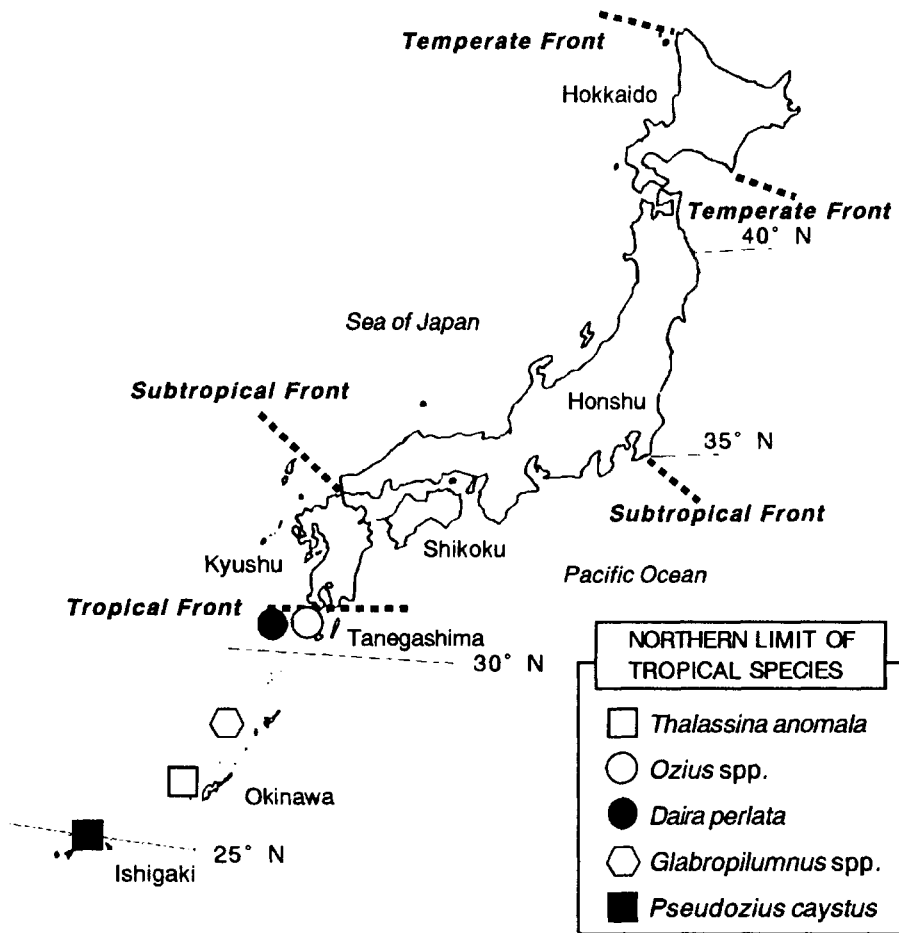


Fig. 8. Northern limits of extant tropical species which are allied to fossil species.

A change of the component species on the lower sublittoral to upper bathyal facies contrasts well with that of the intertidal to upper sublittoral facies during the Neogene I-II (fig. 6). Decapods occurring first in the Neogene I survive beyond the Neogene II and some of these species disappear in the Neogene II. Species surviving beyond the Neogene II become extinct in the Neogene III. Decapods of the Neogene IV have nothing in common with those of the Neogene III except for *Cancer sanbonsugii* Imaizumi, 1962. *Carcinoplax* H. Milne Edwards is one of the commonest decapod genera of the Japanese late Cenozoic. *Carcinoplax antiqua* that occurred abundantly in the Neogene I-III is represented by the different species, *Carcinoplax granulimanus* Karasawa & Inoue, 1992 and *Carcinoplax imperfecta* Karasawa & Inoue, 1992 at that time. Differences between the Neogene IV and V are recognized by the absence of common species. *Car-*

cinoplax granulimanus and *C. imperfecta* became extinct prior to the Neogene V and *Carcinoplax prisca* Imaizumi, 1961 appears in Neogene V. The component species change between Neogene V and VI. *Carcinoplax prisca* disappears in the Neogene V and the extant *Carcinoplax longimanus* first appears in Neogene VI. In the Pleistocene-Holocene the component species consist of extant taxa with the exception of five extinct species. As a result, the major change which is characterized by the extinction of decapod species is clearly recognized between the Neogene II and III, the Neogene III and IV, Neogene IV and V, and Neogene V and VI. A change of the species in the genus *Carcinoplax* represents the major changes well.

Barron & Baldauf (1990) recognized three warm phases which are characterized by a low oxygen value from the North Pacific Ocean during the Miocene and termed them "climatic optimum 1" (16-14.9 Ma), "climatic optimum 2" (11.5-10.4 Ma) and "climatic optimum 3" (7.6-6.6 Ma), in ascending order. Tsuchi (1990) also recognized a "warm episode" at 3.0 Ma as a climatic event in the Pliocene.

The major change in the lower sublittoral to upper bathyal facies appears to coincide with climatic events such as "climatic optima" and the "warm episode". The warm interval of "climatic optimum 1" corresponds to the interval zone of the Neogene II. Most Miocene endemic genera and some species become extinct at the end of this warm interval. During the cool interval between 14.9 Ma and 11.5 Ma the surviving species disappear. The warm interval of "climatic optimum 2" correlates with the interval zone of the Neogene III and some species first appear at that time. Although there is a wide fossil barren zone in the late Miocene, first appearances of species are recognized after the warm interval of "climatic optimum 3" and the "warm episode" (ca. 3 Ma).

In the intertidal to upper sublittoral facies of the Neogene II, species increase in number and the appearance of tropical species is recognized. It correlates with the warm interval of "climatic optimum 1".

Generally speaking, the appearances of decapod species took place in the warming phases and their extinction occurred in the cooling phases. The late Cenozoic decapod fauna consists of many Indo-West Pacific and widespread genera which have tropical and subtropical distributions. These genera appear to be of tropical origin. An example is the Indo-West Pacific genus, *Carcinoplax*, which increases in number of extant species from high latitude to low latitude areas and seems to have the South China Sea as its center of dispersal (Guinot, 1989). Then it seems that decapod species migrated from the south to Japan in relation to warming events and that their extinctions were caused by cooling events during the late Cenozoic.

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